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U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN No. 134.

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# TREE PLANTING ON RURAL SCHOOL GROUNDS.

BY

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## LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,  
BUREAU OF FORESTRY,

*Washington, D. C., July 2, 1901.*

SIR: I have the honor to transmit herewith a paper entitled Tree Planting on Rural School Grounds, prepared by William L. Hall, Assistant Superintendent of Tree Planting of the Bureau of Forestry, and to recommend its publication as a Farmers' Bulletin. The paper deals with the present condition and needs of rural school grounds and indicates methods for their improvement. It also suggests important lines of study for the teacher and school in connection with trees and forests. The information and advice apply to country churchyards and to schoolyards in many towns and villages.

As the preparation of this paper involved some consideration of landscape architecture, the subject of which is outside the province of the Bureau of Forestry, the paper was referred to Mr. Frederick Law Olmsted, jr., of Massachusetts, an authority on landscape architecture, to whom acknowledgment is due for valuable suggestions.

Respectfully,

GIFFORD PINCHOT,  
*Forester.*

HON. JAMES WILSON,  
*Secretary of Agriculture.*



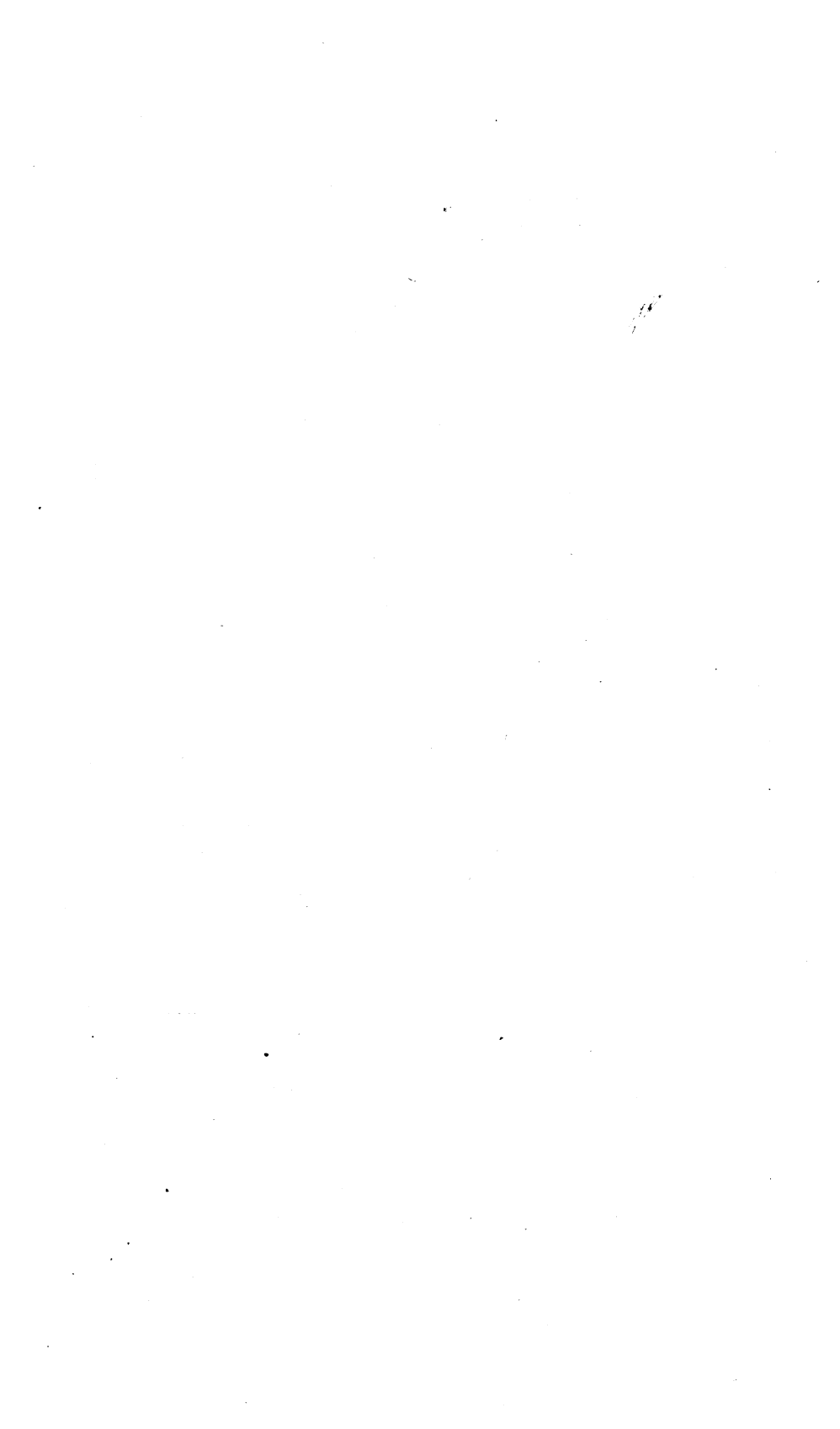
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# TREE PLANTING ON RURAL SCHOOL GROUNDS.

## INTRODUCTION.

A great number of schoolhouses in the United States lack the surroundings that make for comfort and contentment. City school grounds are often so small that planting is out of the question, though, where space permits, it is not uncommon to find them carefully laid out, with a good arrangement of grass plots, flower beds, and shade trees. In towns and villages, also, may be pointed out many examples showing great care and attention. In the country, however, an improved school ground is rarely found. In hilly, forest regions they are often denuded of soil and full of stones and stumps, and on the prairie many are well-nigh as bare, bleak, and inhospitable as when they formed a part of the unsettled plain.

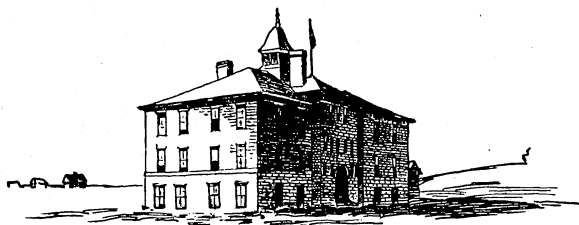


FIG. 1.—A town schoolhouse in a prosperous agricultural region, entirely unprotected.

This lack of improvement is not due to causes evident at first sight. It is not on account of poverty, for it is almost as common in wealthy as in less prosperous communities. (Figs. 1, 2, and 3.) It is not due to lack of appreciation of the elements of beauty, for where homes are surrounded with trees, grass, and flowers the school ground is likely to be entirely neglected. Neither is it due to indifference in educational affairs, for none are more cordial in their support of school systems and institutions of learning than the American people. The cause seems to lie rather in the failure to see the importance of comfort and beauty in education and to realize the interest of the American youth in the natural world around him. Some err so far as to mistrust the willingness of the boys and girls to allow trees and shrubs to grow unmolested on the school ground. This is a flagrant misinterpretation of the spirit of childhood. With a better understanding

of youthful nature, one sees an easily awakened regard for things beautiful and a disposition to respect and help all well-directed activities for the improvement of school life.

### REASONS FOR SCHOOL-GROUND PLANTING.

**Protection.**—The strongest reason for school-ground planting is for the comfort of the teacher and pupils who occupy the building from seven to nine months each year. A schoolhouse so situated as wholly to lack protection from inclement weather often subjects its occupants to distressing conditions. During winter gales there is an increasing demand for fuel, which, though supplied, often does not suffice to

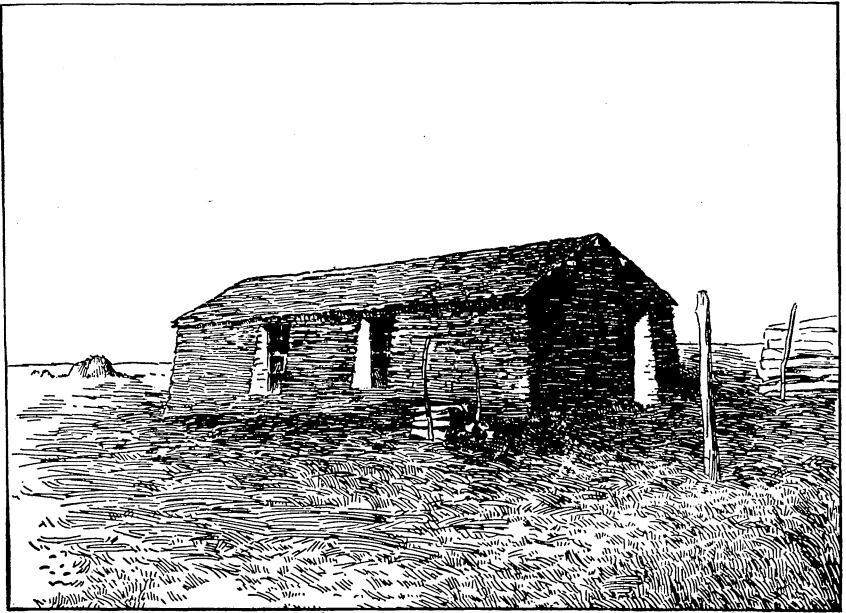


FIG. 2.—Unprotected sod schoolhouse on the Great Plains.

keep the building warm. The teacher is then put to test contriving methods by which no pupil shall endure more than his share of cold, and by which to maintain the usual good order during study hours and provide for indoor recreation at the rest periods. With the temperature hovering around the zero point during a howling blizzard, one has but to enter a country schoolroom to appreciate its discomforts and see its need of protection.

The winds of spring are almost as trying as those of winter, and in summer the sun beats down with unchecked violence. Thus each season is accompanied by ill effects for those who must attend school where the grounds are exposed. The question naturally arises: May

not these conditions be remedied? To this the answer certainly should be that they may. They have been remedied in some instances, and can be in others. It is not too much to say that in nine cases out of ten exposed school grounds can be rendered comfortable by trees planted in wind-breaks.

**Educational Value of Trees.**—But comfort is not the only reason for planting about the schoolhouse. The trees have also an educational value. Indeed, bare grounds may be regarded as an opportunity. Children interested in the work of selecting, planting, and growing trees and shrubs about the school can gain in the work no little knowledge of right principles and methods. Many people think that to

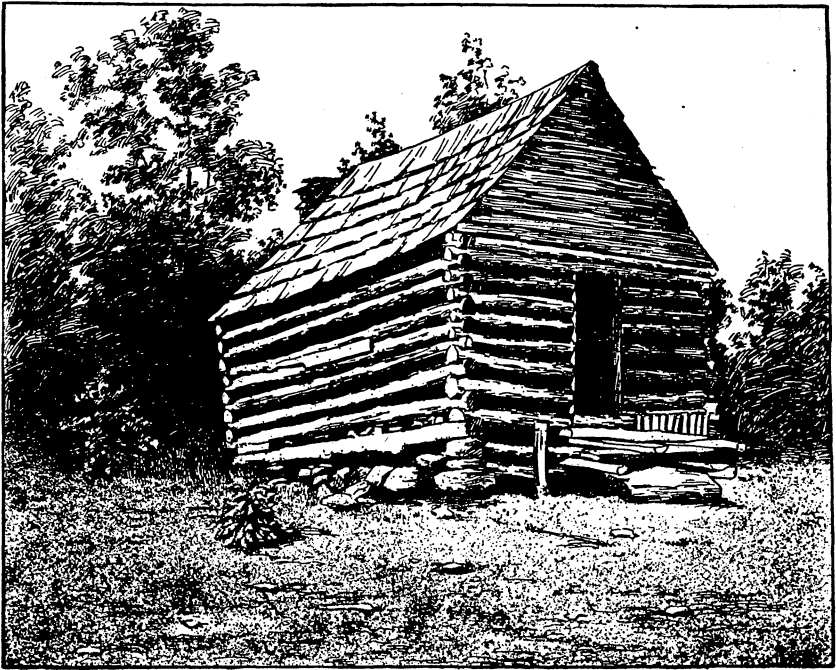


FIG. 3.—Neglected schoolhouse on a forest hillside in the South.

plant a tree all that needs to be done is to dig up a sapling, or buy it, and set it in a hole. This is a great mistake, responsible for many unnecessary failures. Some knowledge of tree culture is a thing sure to prove useful to a large proportion of school children.

Forestry is beginning to attract attention as a possible subject of school instruction. So far the interest in it is mainly as a branch of nature study, but its growing economic importance may eventually result in its extensive introduction into courses of study. Technical forestry can not be taught in the schools as part of a general education, and it ought not to be supposed that tree planting on school

grounds looks in that direction. Nevertheless a plantation of forest trees or a wood lot, in connection with a school, would give an excellent opportunity for study of forest growth and management, and in many places it is perfectly feasible. (Fig. 4.)

But there is another side to the educational value of tree planting, which is of first importance. It is money well spent to make the



FIG. 4.—Interior of a thrifty forest belt, showing an excellent opportunity to study the growth of trees.

schoolhouse and everything about it attractive and beautiful. Here is one of the centers of the life of the community, the one in which is gathered its most impressionable element. The school is supported at public expense in order to make good American citizens. It aims at securing the highest possible development of mind and character. Every element of order, neatness, and beauty, every broadening influ-

ence, every appeal to the finer nature of the child means better men and women and a more thrifty, prosperous, and attractive community. Americans are justly proud of their school system, and should be willing to support the schools not only with money, but with time and labor.

### **ARBOR DAY AND SCHOOL-GROUND PLANTING.**

The neglected condition of the school ground has not remained without notice or without some effort toward improvement. The sentiment in favor of school-ground comfort and adornment has gradually increased for the last thirty years, and has been greatly aided by the establishment of an annual Arbor Day for tree planting. Arbor Day was proposed by Hon. J. Sterling Morton, ex-Secretary of Agriculture, and was first observed in Nebraska, where it was officially recognized in 1872. It was first associated with school-ground planting in Cincinnati, in 1882, in connection with a meeting of the American Forestry Association. Since then it has been best known by its observance in the schools. All the States have followed the example of Nebraska in establishing Arbor Day, and the movement has now spread into many foreign countries. Great Britain, France, Spain, Japan, and New Zealand all celebrate their Arbor Days.

**Method of Celebrating Arbor Day.**—The governor of each State annually appoints Arbor Day at the proper season for planting. This day is celebrated in the schools by public exercises appropriate to tree planting, with essays, songs, and recitations by the pupils, and addresses by visitors. In connection with the exercises there is ordinarily more or less tree planting. Great care is taken to make the planting ceremonies impressive by letting the children take part, and by planting trees commemorative of noted persons or events. Much more attention is given to these matters than to having the trees in the best condition and to planting them just right.

As might have been expected, the results upon the school grounds have not been marked. Too often the work has been impulsive and the interest transient. Trees planted with ceremonious dignity in April have died of neglect before September, and those that survived have been left to fight unaided their battles for existence. So little attention has been paid to the choice of trees and to the methods of planting that those entirely unfit for the situation have often been used, and have been planted in places where they could not receive protection while young, or serve any useful purpose when grown. Arbor Day has often come on dry, windy days, or clear out of season for planting. Furthermore, the planting has been on too small a scale to be of great benefit. Where an acre of trees in a solid block is needed, only a half dozen specimens have been planted. After all that has been done, the school grounds are still largely unimproved.

The educational results of Arbor Day endeavors, however, have been extensive and beneficial. Even though the celebrations have been largely exhibitions of sentiment and the planting almost wholly unsuccessful, yet pupils, teachers, and parents have learned much about trees as useful, living things, and about forests as great sources of national wealth to be protected and perpetually maintained. The smallness of the results has itself drawn attention to the inadequacy of past methods. It is due in part to lessons learned in Arbor Day planting that we are now ready to begin work with a better understanding of what is to be done.

**Necessity for better methods.**—The need of the school grounds is for plantations of hardy trees, cared for by such methods as will keep them constantly thrifty. The trees should be selected and planted in the most careful manner. They should be properly placed, and in sufficient number. To plant in this way requires a great deal of attention to details. It may be the work of several days. The perishable nature of trees also makes it extremely important to plant them when the weather conditions are just right. Dry, windy weather may cause several days' delay in the planting. It is therefore impracticable to depend wholly on a specified day for the work. Let the trees be planted at the right time; then, if public exercises are planned, they may be held on an appointed day after the planting is completed.

Many difficulties at present encountered may be overcome by placing the direction of the planting in the hands of some person who understands fully its purpose. The pupils should assist in the work because it is for their own school ground, but on account of their lack of experience they should work under competent supervision.

### **PRELIMINARY ARRANGEMENTS FOR PLANTING.**

A movement to improve the school ground is likely to encounter many obstacles. The first, and perhaps the most serious, is public indifference. Then there are the difficulties of getting started on the right planting plan, of finding methods to carry it out, and of having the planted trees properly cared for during both the school year and the vacation period. These are formidable obstacles, as many persons experienced in school-ground planting will testify; yet they have been overcome in a large number of cases, and will continue to be overcome, for every school ground successfully planted will not only induce other districts to undertake the work, but will reveal the methods by which it may be accomplished.

To be of permanent value the planting must be a matter of concern to the whole district. The teacher and the school can not accomplish the work unaided by the parents, neither can the parents accomplish

it without the aid of the teacher and the school. Only when all work in unison can the best results be obtained. Unfortunately there are sometimes persons in the district who have no interest in improvement, and it may even happen that they control the school board, while those who have an intelligent interest in the matter may be few in number, and even the teacher may be too deficient in knowledge of planting to give valuable assistance; but such a situation as this is not hopeless if the few persons who desire to make improvements know how to bring things about.

**The Planting Plan.**—The first step is to prepare a plan. This should be a detailed outline of the planting based on a complete analysis of the situation. It should embody a map of the grounds, with the school-house, outbuildings, and place for planting the trees accurately located. If the plan is presented at a meeting in the schoolhouse, a blackboard drawing should be made showing the school ground and exactly what planting is proposed. In this way its advantages can be more clearly pointed out, and its defects, if there be any, will also be pointed out and remedied.

It is scarcely to be expected that a plan will be made which will suit all; so here, as in other matters that concern communities, the majority should rule. It is always to be hoped that the school board, the teacher, and those most active in the improvement of the community will be in perfect accord. If points of difference arise and are not settled after candid discussion, they should be referred to disinterested persons or dropped out of the plan entirely.

**A District Policy.**—While undue haste in adopting a plan should be carefully avoided, it should be remembered that many good movements fail by not being properly prosecuted. If the district adopts the policy of establishing and permanently maintaining a plantation of trees and shrubs on the school ground for ornament, protection, and improvement, a great advance will have been made; but until this has been done there is no guaranty of lasting results. It is easy to arouse the tree-planting spirit in the school, but unless this interest has the support of the district it is likely to wane and languish. The teacher can not take the responsibility, for his tenure of office is liable to be short. Both teacher and school must be among the chief agencies in carrying out the work, but only according to the general plan, judiciously directed by the district authorities. The appropriate celebration of Arbor Day as a part of the plan will aid greatly in the promotion of education and sentiment in tree planting.

As soon as a policy of planting is adopted, some experienced person should be appointed to superintend the preparation of the ground, the procuring of the trees, the planting, and the subsequent cultivation. Such services must usually be paid for, but they are well worth the cost.

### WHAT PLANTING TO DO.

There should be both purpose and method in school-ground planting. The trees must be so arranged as best to serve both for protection and for ornament. At the same time, to grow well they must be adapted to the soil. On a small ground but little planting is possible; a group of trees or shrubs placed where they will look well or hide some unsightly feature of the schoolhouse or ground is sufficient. But in the country there is usually an acre or two of grounds. The schoolhouse is nearly always in the middle, and the playgrounds are usually about halfway between the building and the outer boundary. This

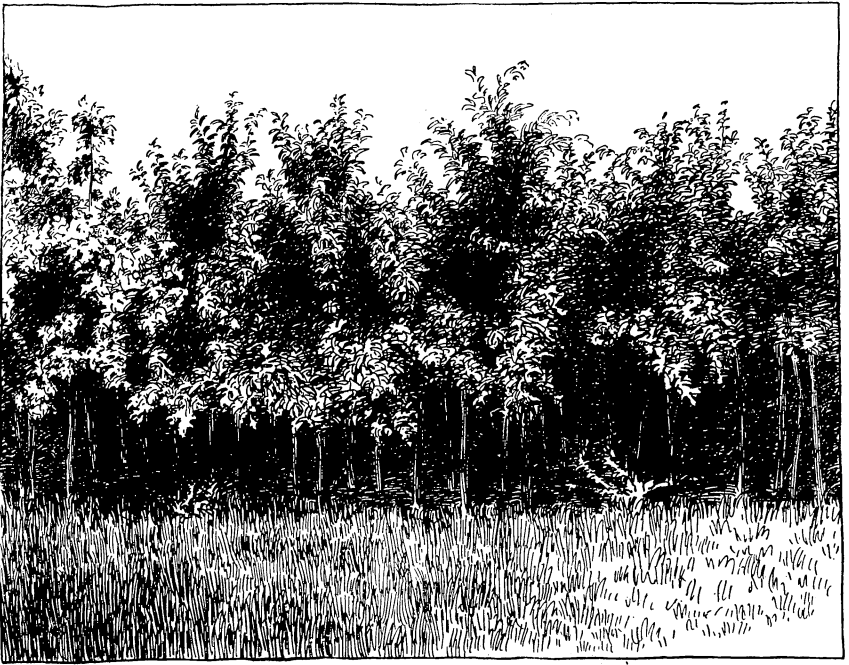


FIG. 5.—A suitable belt for the rear of a school ground.

arrangement leaves open the outer portions of the ground, where the greater part of the planting is needed.

By so planting, the schoolhouse will be protected on all sides from the wind, while in summer shade will be provided near all portions of the open playground; at the same time inclosing the ground with a border of trees will give a pleasing ornamental effect. Instead of being continuous around the ground, the border should be broken in places to preserve attractive views of the exterior landscape.

The general directions here given may be helpful in affording suggestions, but without modification will seldom be fully adapted to par-

ticular cases. The general condition and size of the grounds, direction of prevailing winds, slope, and surroundings should collectively determine the character of the planting.

**A Rear Belt.**—In many cases the first necessity is to plant a belt of trees across the rear of the lot. If the ground is large, this may be several rods wide and cover an acre or more. Possibly it may be extended around the outbuildings so as to hide them from view. Solid planting should be the rule. But it often happens that the rear views from a schoolhouse are quite as attractive as those toward the front. In that case the planting must be planned so as to preserve them, while hiding the unattractive features and giving the necessary protection to the ground and building. Figure 5 shows a good belt of trees for the rear of a school ground, where solid planting is desirable.

**Other Planting.**—After the rear belt, the side planting is of the most importance. Here again the trees should be in belts. To allow room for a playground it may be necessary to make the side belts narrower than that in the rear. Openings in them for walks or views of the exterior landscape may also be desirable, but these need not affect the general plan.

A formal arrangement with the trees in straight rows along the sides of the lot will in many instances be appropriate and satisfactory. It gives opportunity for cultivation, and is both simple and attractive. On large grounds a better effect will often be produced by spacing the trees irregularly. Some attention will be required to leave passages open for cultivation without the trees appearing to stand in rows. The appearance of the entire ground will be improved by varying the width of the belts so that they will project into the interior open space in some places, and in others retreat almost to the boundary of the ground.

The front ground in most cases should not be solidly planted. If it is necessary to hide objectionable buildings and other objects on the front and sides or to prevent the trespassing of stock, either a hedge or an irregular belt of shrubbery may be made to serve the purpose. Two or three groups may be introduced where they will not interfere with the playground or obscure attractive views. Fig. 6 shows an entire front yard shaded by trees planted in regular rows. This is a very poor arrangement, for it shuts off the view and robs the children of their playground.

Where several kinds of trees are used in the belts, they should be mixed by groups and not by single trees. Here will be a group of vase-like elms, there a group of sturdy oaks, yonder one of pines. Such grouping gives character to the planting when seen near at hand, and variety at a distance, where only the tops of the trees are visible, outlined at different heights against the sky.

A little shrubbery rightly used gives a charming effect to a school yard, although many grounds are well planted without it. It finds its place in clumps against the belts of trees, in corners, and in front of objects that should not be in view. Banked against the tall trees the



FIG. 6.—Front ground heavily shaded, rear ground open—a poor arrangement.

tall-growing forms may be used, but around objects to be screened from view the shrubs should be only high enough to answer the purpose. If planted around the house to hide a rough foundation wall, only low-growing forms should be chosen.

### KINDS OF TREES TO PLANT.

Persons unskilled in planting are apt to choose inappropriate trees. Fancy leads them to use odd kinds and to form grotesque combinations which fulfill none of the purposes of planting. Besides, the use of such trees is likely to be very costly on account of the high prices charged for them and the labor required to make them grow. Fortunately, the best trees for planting are easily obtained, because they are usually those common in the locality.

**Hardy Trees.**—The first rule to lay down is to plant only the kinds that are known to be hardy. A school-ground plantation is no place for experiment. Naturally the trees will have to endure greater hardships than those of a private plantation; they will be likely to have less cultivation and be subject to more abuse. No matter how strict the rules, the soil about them will be more or less trampled, and twigs

will sometimes be broken from their tops. Any tree that can not endure moderate abuse of this kind should not be given a place on the school ground.

On account of difference in the soil, a tree that thrives in one place in a locality may not thrive in another place. Sandy soils and clay soils are often found near together, and trees that grow thriftily in sandy soil may have a hard struggle to exist when planted in clay. For this reason both the soil and the subsoil of the school ground should be carefully examined, and a list should be made of trees in the neighborhood that are thriving on soils of the same character, and no other species should be used. Much better success may be expected with a soil and subsoil of a porous character than with one that is tenacious and impenetrable. Yet a careful study will show numerous species adapted to each kind of soil.

**Trees Easily Obtained.**—Elms, oaks, and maples are to be had almost anywhere, and are easily transplanted. They are as beautiful as any trees to be found, and are in every way well adapted for the school ground. They grow on a great variety of soils, and can be easily raised from seed if young trees are not available. Every region will afford other valuable sorts, such as beeches, chestnuts, walnuts, ashes, pines, or spruces. From these and such other desirable kinds as the locality affords the selection should be made.

**Short and Long-Lived Trees.**—The school ground being permanent and the need of trees continuous, for the most part long-lived trees should be used. But where the present need of trees is great, there is another side to the question. A short-lived tree grows quickly, coming into early usefulness, and serves its purpose for from twenty-five to fifty years. A long-lived tree usually grows more slowly, but serves its purpose for a century or more. In many cases it is advisable to use the two kinds in such a way that the long-lived trees will become useful about the time the short-lived trees reach maturity. The latter can then be removed, leaving the ground to the long-lived trees. In all cases an ultimate stand of such trees as elms, oaks, walnuts, or chestnuts should be the aim.

**A Variety of Species.**—It may seem that the number of kinds which can be used for school-ground planting is small, but this is not the case. In almost all sections of the country a long list of species fully adapted to the purpose can be made out. In selecting among these the aim should be to give the plantation as much variety as possible, since among other purposes it is to serve that of instruction.

### OBTAINING THE TREES.

**Forest Seedlings.**—In many places trees can be obtained from the neighboring forest, from the banks of streams, from plantations, or even from open fields. If they have had normal conditions of growth and

are taken at the right time, they are almost as valuable for planting as nursery-grown seedlings. Pine, spruce, and cedar are to be collected in unlimited numbers in many forests, and frequently ash, maple, and elm are almost as abundant. They may be gathered either in the fall or spring, but unless they are very carefully heeled in and protected over winter the better time is early spring. In collecting forest seedlings only the small trees that have grown in the light should be taken, as these are more likely to be young and vigorous than



FIG. 7.—A small forest tree nursery.

those grown in the shade. The collector should never pull the trees from the ground, but should dig them carefully with a spade, preserving as much of the root as possible. As each tree is dug it should be placed in a barrel containing water until all are collected, when they may be heeled in together, as described for stock purchased from a nursery (page 22). The pupils will be eager to enter into this part of the work, and, under the direction of the teacher or superintendent of planting, they can do it as well as anyone. It will be a pleasure to them, and the knowledge gained will be valuable.

**Home-Grown Seedlings.**—If wild seedlings can not be collected and it is not convenient to buy the trees from a nursery, it will be necessary to grow them from the seed. This method has the advantages of being economical and of supplying the stock exactly at the time needed. It is an easy matter to grow forest seedlings, and to one who likes trees it is a pleasure. The superintendent of planting should arrange to have the seedlings grown by some reliable person, and it will be helpful to have the school children assist in gathering and planting the seeds. (See fig. 7.) If grown from seed, the trees will usually need to remain in the nursery only one or two years. Just before time for planting they should be taken up and heeled in so that they will be in readiness when wanted.

**Trees from a Nursery.**—The most common method of obtaining forest trees in regions remote from the natural woodland is to purchase them from a nursery. Nearly all nurseries grow trees for ornamental planting, and a number in the prairie States offer stock for forest planting. Where large quantities are handled, the trees are usually sold as seedlings when one or two years old, and are quoted by the hundred or thousand, the price for ordinary kinds ranging from \$2 to \$7 per thousand. Ornamental trees are sold at the age of from three to five years, after having been transplanted once or more. They are sold by the single tree, or in small quantities, at prices ranging from 10 to 25 cents each.

As a rule there is little to be gained by planting large trees. If only a few are to be planted and the best of care can be given them, trees 8 or 10 feet high, or even larger, may be used, and are much less likely to be injured after planting; but if a number are required, smaller trees are better. Besides costing much less, they are not so bulky, and are, therefore, less expensive to ship, less difficult to plant, and are always transplanted with greater success than larger ones. Fig. 8 shows a good size. This tree is two years old and 36 inches high.

The trees should be on hand as soon as the freezing is past in the spring. To insure delivery at the proper time, they should be ordered two or three months beforehand. It is usually best to order from a



FIG. 8.—Box Elder seedling, two years old, 36 inches high, showing a good size for planting.

nursery in the same region, and, if possible, one which can ship over a single line of railroad. Every precaution should be taken to prevent delays in shipment and transit, and the receiver should be ready to care for the stock when it arrives.

As soon as the trees are received, they should be unpacked and prepared for heeling in by placing the roots in a thin mixture made by stirring together earth and water. They should remain in this while a trench is being dug, deep enough to bury the roots and about half of the tops. It should extend east and west, with its south bank sloping at an angle of about  $30^{\circ}$  with the surface of the ground. In this is placed a layer of trees, with their tops leaning south and their roots and trunks covered and well packed with fresh fine earth taken out on the north side of the trench. In the trench thus formed on the north side of the first layer is placed a second layer, with the tops leaned over on the first and covered in the same way. This operation is continued until all the trees have been heeled in. They should be left in this condition until the time of planting.

### HOW TO PLANT THE TREES.

**Preparation of the Soil.**—Thorough preparation of the soil should precede the planting. Where blocks or belts are to be formed, the ground should be plowed and prepared as for a garden crop. Clay soils are best plowed the previous fall, in order that the ground may weather over winter. On such soil subsoiling is beneficial, and should precede the planting by at least one season. Just before planting time the ground should be pulverized with a roller or harrow. If the planting is to be done in rows, the ground should be marked off lengthwise and crosswise and the trees set at the intersections. It is sometimes desirable to mark off the ground only one way and run furrows the other. In arid regions the furrows may be deepened into trenches, so that rain water which falls on the surrounding ground may be drained to the tree. On the other hand, in regions having a copious rainfall it will frequently be necessary to plant the trees on a raised portion or mound of earth in order to keep the soil dry enough for them to thrive. The holes should be dug large enough to contain all the roots fully spread out, and deep enough to allow the tree to stand about 3 inches lower than it grew as a seedling.

**Time and Manner of Planting.**—South of the thirty-seventh parallel, fall planting is safe and often advantageous. North of this, spring planting should be the rule, as fall-planted trees can scarcely develop sufficient roots to sustain themselves during the winter. The most successful nurserymen practice early planting for deciduous trees, beginning operations as soon as the ground ceases freezing. Evergreens are not planted until later; some even wait until the young

growth is starting. If possible, planting should be done on a cool, cloudy day. Unless the day is very moist, the trees should be carried to the planting site in a barrel half filled with water, or a thin mixture of earth and water, and lifted out only as they are wanted. Even a minute's exposure to dry air will injure the delicate roots—the feeders of the tree.

The roots should be extended in their natural positions and carefully packed in fine loam soil. It is a good practice to work the soil about each root separately and pack it solid with the foot. As the hole is filled, the earth should be compacted above the roots and around the stem, in order to hold the tree firmly in place. The last 2 inches of soil should be very fine, and should lie perfectly loose. It will serve as a mulch to retain the moisture.

Trees should be planted neither in very wet nor in very dry soil. If the soil is wet, it is better to wait until it is drier. On the other hand, if good cultivation has been maintained the year previous to planting the soil is not likely to be so dry that trees will not start. Besides insuring a supply of moisture, such cultivation puts the ground in good physical condition for planting.

With this treatment watering will scarcely ever be necessary. If it is, the holes may be dug a few days beforehand and filled with water. They should be refilled as the water soaks away until the soil is fully moistened. A thorough irrigation, when that is possible, is still better. As soon as the soil becomes somewhat dry the trees should be planted. While it is a common custom to water at the time of planting, those who do no watering are usually the most successful. Even in the semiarid regions some successful growers apply no water, but keep up an excellent system of cultivation, thereby retaining the soil moisture.

The spacing of the trees is not so important in school-ground planting as in forest plantations, yet it is worth consideration. The trees should not stand so near together as to produce long, slender poles; on the contrary, short, thick trunks are desirable, to support large tops and withstand heavy winds. From 8 to 12 feet apart will be suitable spacing distance. Where large blocks are to be planted the trees may be closer, but it is scarcely ever desirable to plant them closer than 6 by 6 feet.

### **WHY TREES DIE IN TRANSPLANTING.**

To many persons it is a mystery why trees die after being transplanted. They do not die without cause, however, and when one begins to wither something is wrong. Oftentimes the result is not to be noticed until weeks after the injury; in other cases it is apparent in a few days. After the injury has been done it can be overcome

only by the subsequent growth of the tree. All the assistance that can be given is to make the surroundings of the tree favorable for growth. The following are some of the causes of death among transplanted trees:

**Loss of Roots.**—The loss of the principal part of its root system when the tree is being taken up is a great shock to its vitality, and frequently causes its death. A very large part of the root must be cut off, for usually the space surrounding the tree is filled with fibrous rootlets, myriads of which can scarcely be detected with the naked eye. Almost all of these are lost, as well as many of the larger roots. Mr. D. C. Burson, of Topeka, Kans., last year dug up and measured as much as he could of the root system of a vigorous Hardy Catalpa seedling that had grown from May till November. This six-months-old seedling showed over 250 feet of root growth. By the methods in common use only a fifth, or perhaps as little as a tenth, of the root is taken up with the tree in transplanting. Such loss throws the root out of balance with the top. If the top is not shortened, or in some way protected, the leaves may evaporate more moisture than the roots can provide, resulting in the death of the tree.

**Exposure before Planting.**—With proper subsequent treatment a tree can endure the loss of many roots, but instead of the needed protection it often gets much unnecessary exposure to sun and dry air. This may be in digging, packing, shipping, unpacking, or any other of the various handlings which it undergoes between its removal from the ground and subsequent planting. On a warm day in March the writer saw a bundle of trees in shipment across the plains of Texas without the slightest covering. Before the destination was reached the roots became withered and almost dry, having suffered a hundred times more exposure than the ordinary tree can stand without injury. Not many persons would be guilty of such gross neglect, but the fact remains that exposure causes the death of more trees in transplanting than any other single cause. Exposure can usually be easily prevented, and no one who persists in neglectful practices can hope to be successful.

**Failure to Plant Well.**—The failure to pack the soil tightly about the roots is a common error in planting. It causes injury in two ways: It leaves the tree unstable, to be rocked to and fro or even blown down by the wind; it also prevents the first growth of rootlets from absorbing food. This they can not do unless good, fine soil is firmly packed around them. Clods will not pack snugly. Likewise manure or litter of any kind mixed with the soil may prevent firm packing. Anything that prevents the soil particles from coming into close contact with the roots is sure to be injurious. Another error is in shallow planting. This allows wind and water to lay bare the roots, and in a short time the tree dies. Crowding the roots into too small a hole is a similar

difficulty. Such errors are more often due to lack of experience and skill than to haste. The unskillful planter will hardly plant well, however slowly he may go.

**Wet Soil.**—Trees are often injured by being planted in wet soil. Whether the excessive moisture is a permanent or a temporary condition is likely to make little difference in the results. If it is permanent the water prevents the air from reaching the roots, while if it is only temporary the trampling of the soil over them causes it to stick together so that on drying it becomes baked, leaving them impacted in a hard lump of earth which excludes the air. Excessive air currents in the soil are injurious by drying the roots, but a constant permeation of the soil by the air is necessary to supply oxygen. This process is precluded by either the saturation or the baking of the soil. Undrained pockets occur here and there even in well-drained fields, and are always difficult to deal with in tree growing.

**Drying Out of the Soil.**—Another cause of death is the drying out of the soil. Summer droughts are not unknown in any part of the country, and are very frequent in parts of the Mississippi Valley and on the Plains. Occasionally they are so intense and long continued that it is difficult to make recently transplanted trees survive, even when carefully planted and cultivated. In such a time, those which are poorly planted and cultivated are almost sure to die. Frequently, too, weeds and grass grow up in the plantation and draw off the moisture, thereby greatly diminishing the supply for the young trees.

On a school ground there is likelihood of the trees being injured by the trampling of the soil. The pupils will naturally wish to play among them, and unless they are restrained the soil will soon become compacted. It then dries out very quickly, and in time of drought the trees are sure to suffer, and may be killed.

### CARE OF TREES AFTER PLANTING.

**Cultivation.**—Important as the process of planting is, one can never be certain that a tree planted with the greatest care will live and reach maturity. Much depends upon the after-treatment. In many parts of the country cultivation is absolutely essential, and nearly everywhere a tree will thrive better and grow faster during its early years with cultivation than without it. The purposes of cultivation are mainly to protect young trees from the encroachment of weeds and grass, to keep the soil in good physical condition, and to retain the moisture. Good cultivation is that which serves these purposes without injuring the trees. It does not necessarily include deep tillage. In fact, deep tillage may be positively injurious by breaking off the feeding roots, and is usually not necessary to loosen the soil. Very few soils are too hard for tree roots to penetrate if moisture is plenti-

ful. The best way to retain moisture is by frequently stirring the soil to a depth of 2 or 3 inches. The longer cultivation is continued, the better will be the effect upon the trees. It should not cease in any case until they are well established and prepared to thrive without further attention.

Scattering or isolated trees can not usually be cultivated except by occasionally spading up the earth within a circle of a few feet around them. This is necessary in order to keep the grass and weeds from crowding them and retarding their growth.

The difficulty in tilling a school-ground plantation will come during the vacation period. That is the busy time of the year, when crops must be tilled and harvests reaped. Unless the person in charge is very watchful the plantation is sure to suffer.

**Increasing the Moisture Supply.**—Although artificial watering is not recommended, it is necessary to keep the soil of the plantation moderately moist. Sometimes a great deal of moisture can be added by conducting to the plantation the water that drains from adjacent slopes. A small trench made to correspond with the contour lines of a hill or slope will often gather almost all the surface-drainage water. In the Northwest, trees planted as snowbreaks a few rods from the north and west sides of the plantation will cause the drifts of snow to form just outside of the plantation. The trees will thus be saved from breakage, and a helpful supply of moisture will be added at the edge of the plantation.

**Pruning.**—Within a few years after planting some pruning will be necessary to remove the broken and useless branches and correct any tendency toward crookedness. Much pruning should be done while the trees are young, because the wounds made then are small and will quickly heal. Also, very much less labor will be required to prune at this time than later, because the branches which can be removed with a knife or pruning shears on a two-year-old tree will have to be removed with an ax or saw a few years later. The plantation should be pruned about every third year, but if careful attention is given to pruning when it is young, very little later work will be required. The best season is late fall or very early spring. Good pruning requires care and skill. The best work is done with pruning knife, pruning shears, and saw. The branches should be cut off close to the trunk, leaving no projecting stub or shoulder. The brush should be taken out of the plantation and burned as soon as dry.

**Protection of Trees from Injury.**—The responsibility will devolve upon the teacher to inculcate a spirit of respect on the part of the pupils for the plantation. The best way to do this is to make them feel a responsibility for its success. If they feel a personal pride in it, there is little danger of their giving the trees rough usage by bending or breaking them.

In some rural districts where danger of injury from trespassing stock is not overcome by an ornamental hedge or by the grouping of shrubbery, as mentioned in connection with the planting, the grounds should be inclosed by a fence. A neat paling or a fence of woven wire will answer the purpose.

### STUDIES FOR THE TEACHER AND SCHOOL.

A thrifty plantation of trees or a woodland lot presents a field for varied and important observation, which the teacher experienced in presenting topics of nature study will know how to appreciate. Nowhere can better illustrations be found of the operation of many important biological laws, and the lessons learned here are sure to be remembered, because, once grasped, other examples of the same phenomena are certain to be constantly presented to the awakened attention of the boy or girl.

**Characteristics of Trees.**—Naturally one of the first lessons in this forest work will be to study the different kinds of trees, and to learn the characteristics which separate them into groups; for example, the points of difference between conifers and broadleaf trees, between oaks and maples, and even between one kind of maple and another.

Prominent among the distinguishing characters of trees are their

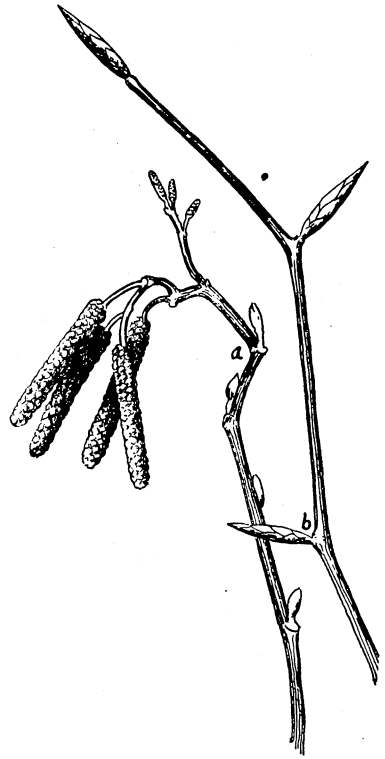


FIG. 9.—Winter condition of twigs and buds:  
a, Smooth Alder; b, Beech.

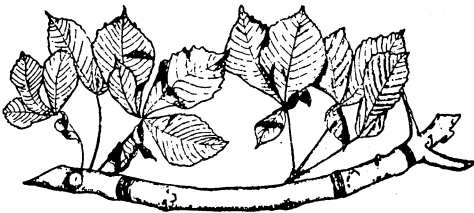


FIG. 10.—Twig of Horse Chestnut, showing leaves and annual growth.

twigs, buds, leaves, flowers, and seeds. Great variation will be found, variation not only in trees of different kinds but in the same tree at different seasons. The summer and winter conditions of twigs and buds of deciduous trees are so different that one can scarcely identify a tree in winter from a knowledge of its summer appearance. Fig. 11 shows the winter condition of twigs and buds of Smooth Alder

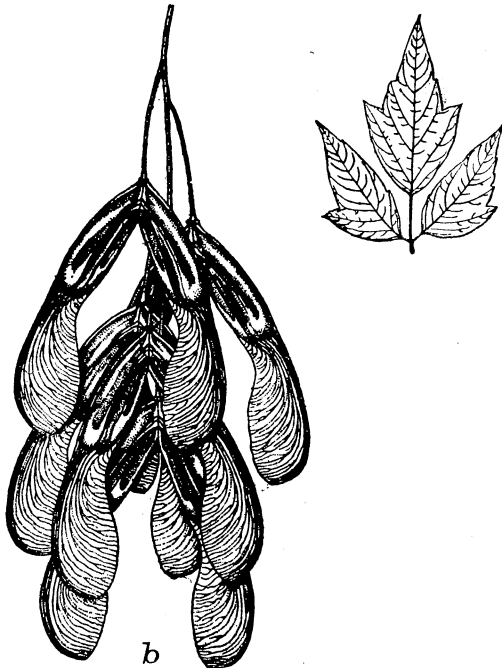
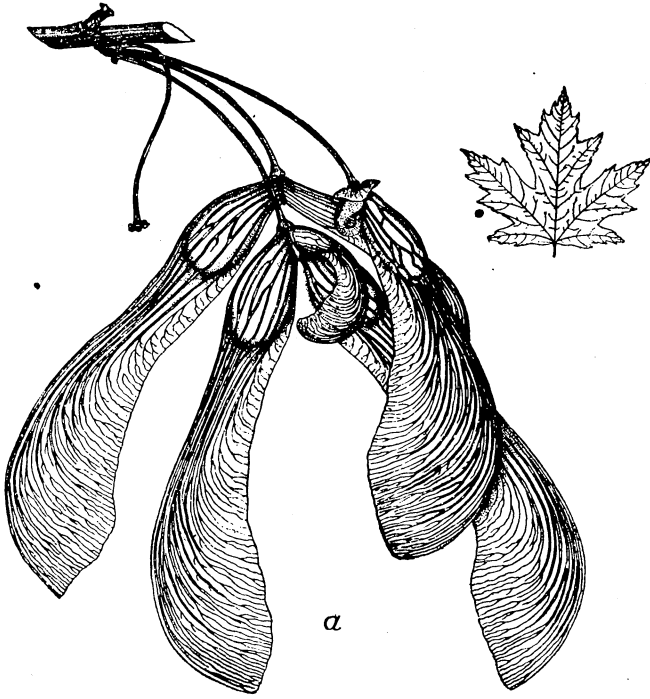


FIG. 11.—Seeds and leaves: *a*, Silver Maple, mature seed (natural size), mature leaf (one-fourth natural size); *b*, Box Elder, mature seed (natural size), mature leaf (one-fourth natural size).

and Beech; fig. 10, the twig and leaves of Horse Chestnut. In studying seeds it is important to notice such points as how they are borne, their structure, shape, size, time of ripening, and means of dissemination. Figs. 11 and 12 show the seeds and leaves of Boxelder, Silver Maple, and White Oak. Fig. 13 shows the late winter condition of acorns after having begun to germinate the previous fall, while fig. 14 shows their condition after a few warm spring days have passed.

**Influence of Soil upon Trees.**—The study of the soil preferences of trees is important, because from it we gain a knowledge of one of the chief factors in tree growth. For this study it is best, if possible, to go to the natural woods, for there will be seen the results of many years of struggle among numerous species with no help from man to aid the growth of one tree or retard that of another. Under such conditions, when one species establishes itself to the exclusion of all others, it may usually be inferred that this species is better adapted to the situation than any of its rivals. This should be kept in mind as one notes the willows and alders thriving in low, wet places, the Chestnut and White Oak upon gravelly ridges, or the change from the broadleaf to the coniferous forest between the base and summit of a high mountain. If the school is not near a natural forest or a mountain, the slight forest growth along a stream, or even a plantation, will afford the teacher many opportunities for investigations of similar character.

**Composition of Soils.**—It is desirable that every teacher should know something about soils. He should be able to distinguish a soil as sand, loam, marl, or clay, and know something of the formation of each, and of its capacity to absorb and retain moisture and heat. Not only the surface soil, but also that part which lies hidden below, the subsoil, should be examined, for both have great influence upon the growth of a tree. Most trees send their roots deep into the ground, and if their course is retarded by a tenacious layer of clay or an impermeable layer of stone, the tree will not attain its full growth and development. Then, it will be found that one kind of tree thrives

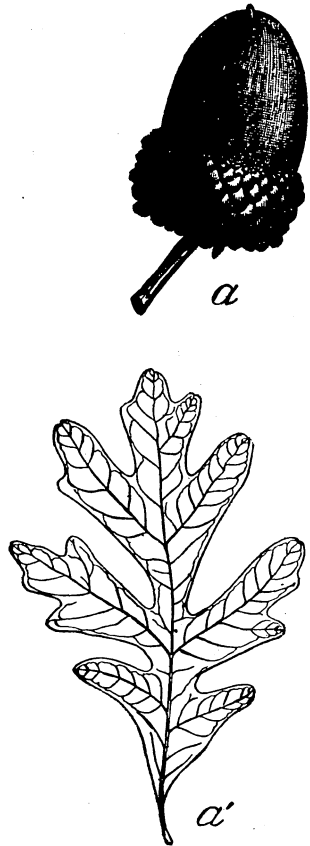


FIG. 12.—White Oak, mature acorn (natural size), mature leaf ( $\frac{1}{4}$  natural size).

on sandy soil, and another kind on clay soil; that one flourishes on a sunny exposure, while another does best on a shaded northern slope;

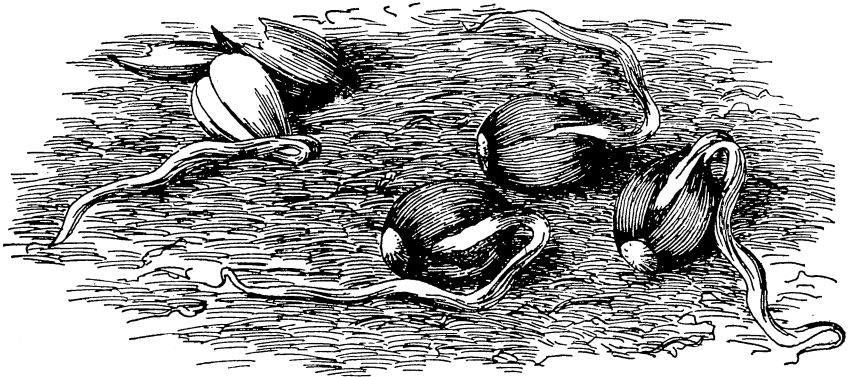


FIG. 13.—Acorns collected beneath a cover of leaves in February. Germination had begun the previous fall.

here is a tree that grows well only where the soil is deep, porous, and fertile; there is one that seems satisfied on the poorest gravelly knoll.

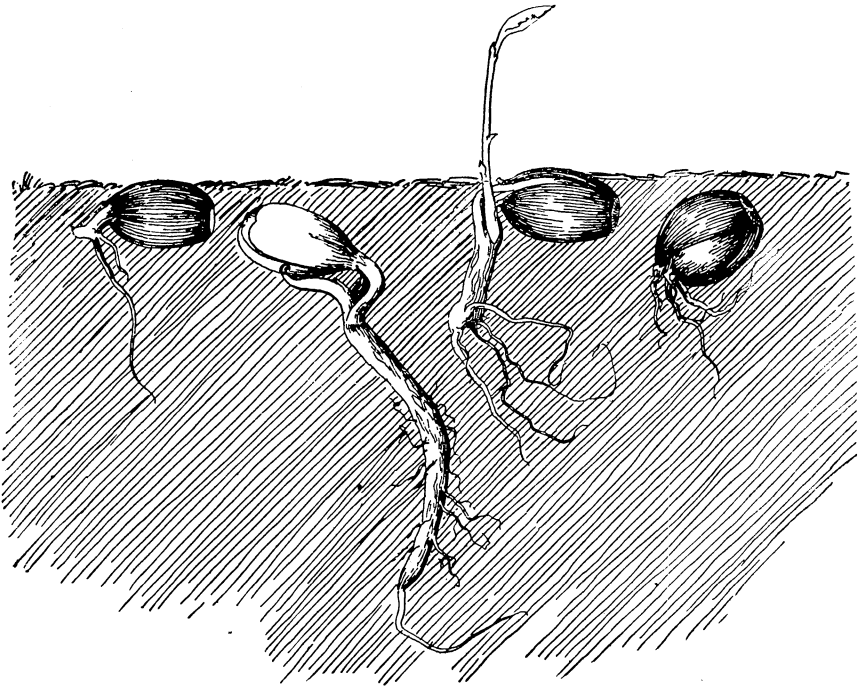


FIG. 14.—Germinating acorns in early spring.

**Influence of Trees Upon Soil.**—While the soil has a great influence upon trees, it is also true that trees have a great influence upon

the soil. Selecting a spot where large trees stand closely crowded together, one may rake aside the thick layer of leaves and see that it has kept the soil moist by preventing evaporation. He may notice, also, that the lower leaves of the layer are wet and moldy. They are beginning to decay. Among them are pieces of twigs, cones, and husks of nuts. All are blackened and appear to be turning to soil. Below this layer is another of the same material, but still more like soil, and in it is a dense tangle of living rootlets of neighboring trees and shrubs. If this soil is examined closely, it will be found that it is not like the soil of long-cultivated fields, composed of small pebbles



FIG. 15.—White Pine under the protection of Chestnut.

and grains of sand, but is made up mostly of decayed leaves, wood, and nuts. Deeper down, this vegetable mold becomes less, and granular particles appear in greater abundance, but it may not be possible to see any but the most gradual change from one to the other. On digging far down into the subsoil one constantly cuts through old decaying roots.

Thus trees are constantly returning vegetable matter to the soil from which they grow. They add to it the mold which gives it its dark color, its power to absorb and retain moisture and heat, and, in a large degree, its porosity and fertility. A dense cover of trees will in time transform the poorest soil into a fertile one.

**Influence of Trees upon One Another.**—Trees are often dependent on one another in their germination and growth. In fig. 15 young White Pine seedlings are coming up under the sheltering branches of a Chestnut. It gives them an increased supply of moisture and partial shade, and nowhere else near by have they come up in such abundance.



FIG. 16.—Oak grown in the open.

Such is frequently the case in the forest. The tender seedlings require the protection afforded by the older trees. There is, however, another phase of this interesting matter. Within a few years the young seedlings reach the stage where they require the sunshine from which they needed protection when young. Then the same overtopping trees that sheltered them in their infancy become a menace to

them. In many cases they grow a few years and die. Now and then one finds a gap among the tree tops and grows up to occupy it, becoming itself a dominant tree in the forest.

The density of trees greatly affects their growth. The isolated tree grows with a short trunk and spreading top, while the crowded one produces a long, slender trunk and narrow top. The difference in form is caused by the effort of the tree to present its greatest extent of leaf surface to the sunlight. Where it stands alone, this is accomplished by the top assuming a spreading or rounded form, but where it is crowded by others and shaded on all sides, it can reach the sunlight only by pushing upward and overtopping its rivals. Hence there is a continual struggle among crowded young trees in their upward growth, and as they grow their lower branches become more and more densely shaded until they die. Decay follows, and soon they drop off, leaving the trunk clear of branches. Fig. 16 shows the extreme form of an isolated tree, while fig. 17 shows the slender upright growth of a tree grown in a forest. Each form has its value and use—the spreading tree for shade and ornament, and the straight, unbranched tree for lumber.



FIG. 17.—Maple grown in the forest.

**Books and Trees.**—For the most part, a knowledge of trees can best be obtained from the trees themselves. There are some things, however, that can be more easily and rapidly learned from books: First, we can learn best from books the important things to look for, or what to study; second, many inaccessible kinds must be studied from books or not at all; third, there are some things about trees that can be more readily learned from books than from experiment, such as how to handle, transplant, and cultivate them.

Knowledge will be gained much more quickly, and will be more comprehensive and much less likely to include erroneous notions, if obtained not alone from the natural objects, but in part from the best works on the subject. So, in silvicultural studies, that teaching will be most valuable that leads the pupil into both original investigation and the study of books.

### FACTS ABOUT TREES.

**Life Processes.**—Trees are living things with vital functions and parts. They have systems of digestion, assimilation, and respiration, with specialized organs for carrying on the various processes, much the same as animals. In correspondence with most of the vegetable kingdom, their leaves have the power under the action of sunlight to absorb carbonic acid gas from the air, to break it up, and, with the carbon obtained and water, to form starch. The oxygen is returned to the air unused. The water comes directly from the soil through the roots and stems, and carries in solution mineral compounds which enter into combination with the starch, forming the more complex compounds such as the tree can readily utilize. These are drawn away to the branches, stem, and roots, there organized into living substance, and made a part of the tissues of the tree.

To carry up the supply of minerals from the roots to the leaves, much more water is required than the tree can utilize in the formation of starch. The excess passes off as vapor through the pores of the leaves into the atmosphere, by a process of transpiration.

A tree breathes for the same purpose as an animal. It takes in oxygen and throws off carbonic acid gas. The process is not centered in a special organ, but goes on over all parts of the leaves, branches, and roots. In the leaves the breathing goes on through the pores; in parts of the tree covered by bark it goes on through the lenticels—the small, light-colored, raised spots plainly seen on the young branches of nearly all trees. Breathing is an entirely separate process from that by which carbonic acid gas is taken in through the leaves and oxygen liberated. It goes on both day and night and at all seasons of the year, though more rapidly in summer than in winter.

**Life History.**—A tree has a definite life history as an organism, with periods of growth, maturity, and decline, and characteristic development in matters of form, structure, and size. There is marked difference in the rate of growth of different trees, and even of the same tree at different ages. Most of the pines grow very slowly for the first ten or twelve years, but much more rapidly after that. Other trees, such as the Tulip-tree, grow rapidly for forty or fifty years, and then more slowly. Still others, such as the oaks, have a very regular rate of increase throughout the growing period. Great variation exists in the age at which trees become mature. While some reach maturity at the age of fifty or sixty years, many of the most valuable commercial trees become mature at from one hundred and fifty to two hundred years. The Redwood of California often is not mature before the age of a thousand years. A tree will continue to make some growth through its maturity and decline, though during its maturity its height growth has almost ceased and its diameter growth is slow. Decline begins when the destructive forces exceed the growth forces.

Given the same climatic and soil conditions, one tree will assume one form, another a form very different. The beech will form a round, much-branched top, the Red Cedar a slender tree with a central stem. The oak will reach majestic proportions, the dogwood will become nothing more than a shrub. The hickory will form heavy, elastic wood, the birch that which is light and brittle. The pine will yield resin and turpentine; the oak, tannin; the maple, sugar. Thus each tree preserves perfectly its identity in external form and internal structure and composition.

**Reproduction.**—A tree reproduces either by seeds or buds. In nature, reproduction by seeds is more common, although reproduction by buds is quite as regular as by seeds in some species. The tendency of the locust to sprout from the roots and of oaks to renew growth from the stump are examples of bud reproduction. The forester in handling woodlands depends upon both methods. Such trees as reproduce only by seeds he keeps by leaving seed trees distributed over the land when the crop of timber is cut. Those that reproduce from buds renew their growth from the stumps of the cut trees. Not only does bud reproduction take place when the buds are attached to the parent tree, but also when they are separated from it. A tree may be divided into many parts, each part becoming a new individual. This gives rise to propagation by cuttings, grafts, and buds. Many forest trees can be propagated by cuttings, and nearly all can be grafted and budded.

**Food.**—In harmony with all other living things, trees require food. Their food is composed of the carbon obtained from the air, and the water and mineral compounds obtained from the soil. Carbon, oxygen, hydrogen, nitrogen, magnesium, calcium, iron, sulphur, phos-

phorus, potassium, and chlorine are called essential elements because, with trees as with all other plants, their presence is necessary to thrive. Other elements are absorbed when present in the soil in soluble form, but their absence causes the tree no loss in vigor. The elements are not absorbed separately and alone, for they rarely exist in that condition, but are blended together with one another into compounds. Thus, in water the plant obtains both hydrogen and oxygen. Potassium, nitrogen, and oxygen are often united in the form of potassium nitrate, a valuable plant food.

**Solubility of Plant Food.**—Trees are able to absorb the mineral compounds only as they are in solution in the water taken up by the roots. Many compounds of the soil which contain valuable food elements are insoluble in soil water, and therefore unavailable. Thus, while potassium is an essential element, it may be in such combinations with aluminum, silicon, and other elements as to be insoluble and useless. Chemical changes are slowly going on in the soil by which insoluble compounds are converted into soluble compounds. Cultivation and fertilization hasten such changes, and to do this is one of their chief purposes.

**Quantity of Food.**—When the food of a tree is in available form, the greater the supply the more rapid its growth. Fertile soil has an abundance of food materials, with the result that a tree situated upon it grows rapidly. Sterile soil is deficient in food materials, consequently a tree situated upon it grows slowly. The same cause, together with the conservation of moisture, explains the difference in growth between cultivated and uncultivated trees upon the same kind of soil. The cultivated tree, with its larger store of food and moisture and its protection from the competition of weeds and grass, rapidly outstrips its less fortunate neighbor.

**Essentials to Growth.**—A tree can grow only when supplied with air, light, moisture, and heat.

Air is necessary because it supplies the oxygen used in the process of respiration, and holds the carbonic-acid gas used by the leaves in forming starch.

Light is essential that a tree may carry on its processes of digestion. So sensitive is a tree to light that it will change its form and habit of growth to obtain the quantity it needs. In a thickly planted group the trees on the edge will bend outward, while those in the interior will grow tall and slender, the growth of each hastening in the direction of greatest light. In the absence of light a tree ceases the processes of digestion by which its food is prepared for use, and in a short time even loses the organs concerned in its preparation; that is, the chlorophyl bodies which give the green color to the leaves.

The necessity of moisture is a matter of common observation. Water is one of the chief agents in the nutrition of a tree, as already mentioned, entering into its food in large quantities and serving as a

carrier of food materials from the roots to the leaves. With the diminution of its water supply a tree lessens its growth and sheds part or all of its leaves in its endeavor to survive. If the supply continues to decrease it finally withers and dies. Yet in their demands for water trees differ vastly. Some can thrive only with their roots in constantly saturated soil—as, for example, the Tamarack of the Northern and the Bald Cypress of the Southern States. There is every degree of variation between trees of this character and those of the desert; where the annual rainfall is limited to a few inches.

Every tree is adapted to a certain range of temperature, depending upon its power to endure heat and cold. Some, like the palms, can thrive only with a constantly high temperature; others, like most of the oaks, are adapted to alternating seasons of heat and cold; still others, as some of the birches and poplars, can endure extreme and continued cold, with only a short period each year warm enough for growth. Such adaptations account for the distribution of forests over nearly the whole of the earth's surface not constantly covered by ice, and also largely for the character of the forest in different regions. Temperature and moisture principally determine forest distribution and growth.

**Local Influences.**—Local variations in heat, light, and moisture greatly affect tree growth. It is not uncommon to find very different growth on the north side of a mountain from that on the south side, because the north side is cooler, moister, and not so light as the south side. Consequently trees well adapted to the conditions on the north side will flourish there, while on the south side they will make inferior growth or not appear at all. West of the Mississippi River the forest clings to the margins of streams far beyond the point where it fails on the upland, principally because the moisture and atmospheric conditions along the streams are more favorable to growth.

**Tree Companionship.**—In almost every region certain kinds of trees are found together. This is due to a similarity of preferences in regard to soil, heat, moisture, and light. Two trees adapted to the same conditions will thrive best in the same situation. The White Ash and Black Walnut are good examples. Having similar preferences, they have almost identical ranges and are very generally associated. There is also another reason why trees accompany one another. A tree may so influence its surroundings as to make them favorable to another tree, where otherwise they would be unfavorable. As an example of such influence, the Chestnut on sterile, sandy plains in portions of New England forms a much-branched tree, which shades the ground and keeps it moist and cool. Such conditions are favorable to the germination of the White Pine in that region; consequently it is found coming up abundantly beneath the Chestnut, but not so abundantly on the open, unprotected ground.

**Effect of Change in Surroundings.**—A change in the surroundings of a tree always modifies its habit of growth. If the change is toward more favorable surroundings the result is seen in increased vigor, rate of growth, and size; if toward unfavorable surroundings, the reverse will be true. The stately Tulip-tree of the central Eastern States is said to be a mere shrub in Florida. The reason is that there it is out of its range of adaptation. The White Elm, which grows with tall and vase-like form in New England, in the semiarid parts of Kansas and Oklahoma is low and spreading like an apple tree. Nor is form the only variable character. On the western elm the leaves are fewer in number, smaller, thicker, and much rougher than on the New England tree. In other parts of the tree there are differences of the same kind, though they are not so noticeable as those in the form and foliage. These variations have resulted from the differences in soil and climatic conditions to which the tree has been subjected.

**Gradual Change.**—The difference in form between two trees of the same kind in different localities has come about through gradual divergence of characteristics. To a certain degree changes of this kind can be brought about in practice. When a gradual change is made in the surroundings of a tree a corresponding change takes place in the tree itself. Thus if stock of the New England elm be slowly moved westward through many generations, it will gradually change in form and other characteristics to be like the western tree; and it must be assumed that this change is necessary to enable it to live under its new conditions.

**Sudden Changes.**—Sudden changes in the surroundings of a tree frequently cause its death, because it can not quickly change itself to meet the requirements of its new conditions. The New England elm moved at once to the semiarid West is likely to die, because it is not adapted to the conditions of soil, light, heat, and moisture of that region. In the prairie marshes of northern Indiana there are occasional knolls which once supported thrifty oaks of moisture-loving kinds. Now that the marshes have been drained the drying out of the soil has caused the oaks to die. The change was too sudden. Suddenness and intensity of change often account for the failure of trees to thrive when moved away from the region to which they were adapted. This is also why Eastern trees so often die when moved to the West. This is why nursery stock grown near by can be more safely planted than that grown in a distant region. It is a practical matter, and should be generally understood.

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